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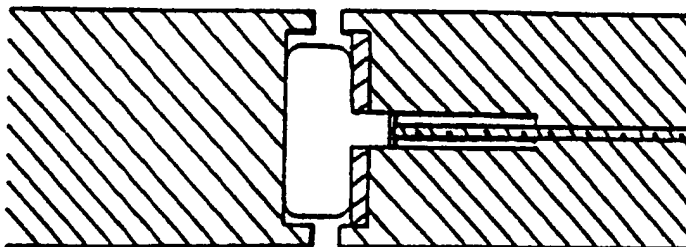
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(54) Title: INJECTION MOLDING OF COMPACT DISCS

(57) Abstract

A method for the injection of molding of compact discs at the very small thickness of 0.6 mm employing a critical sequence of steps during and after the injection of molten plastic into the mold cavity, including allowing the injected plastic to force the mold cavity to partly reopen for a predetermined time (or distance) before closing the mold to its final dimensions.



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INJECTION MOLDING OF COMPACT DISCSField Of The Invention

5 This invention relates to methods for the manufacture of compact discs by an injection molding processes.

Background Of The Invention

10 The invention is concerned with injection molding of 0.6 mm thick optical discs. More specifically an injection molding machine operating under a unique process is utilized to produce 0.6 mm optical discs suitable for lamination to either blank or information side
15 discs.

Injection molding methods and apparatus are known in the art. Injection molding can be generally described as a replication process in which a molten material (usually a polymer) is
20 injected into a cavity and after cooling forms the geometry of the cavity. Injection molding has been used for the mass production of 1.2 mm thick optical discs.

Based on inadequate quality of the resultant product and their slow cycle time the techniques used for mass production by injection
25 molding of 1.2 mm optical discs are not suitable for 0.6 mm discs. The quality requirements for such discs may be expressed in terms of the tilt of the disc (viz. its deviation from planarity), the jitter (viz. the standard deviation of the pit lengths from their pre-
30 determined values), and its birefringence (viz. The stress induced property of polymers to split an incident light beam depending upon its
35 direction through the polymer).

Brief Description Of The Invention

Variations of the injection molding process are used in the replication of optical discs such as CD audio, CD ROM and laser discs. The processes used are suitable because these optical disc formats are all of a 1.2 mm or greater thickness.

A new 0.6 mm optical disc has been developed which offers several advantages over the 1.2 mm format, particularly in the field of high data density optical discs in which data is recorded in a spiral track of alternating pits and lands. Laser light returned to a reading head by such pits and lands is viewed through an optically flat side of the optical disc. Some bending of the light received from a pit or land occurs at the surface of the polycarbonate surface of the optical disc. A thinner optical disc enables the reading laser to employ a smaller spit size and the lenses of the reading head to have a higher numerical aperture when used to readout a pattern of pits and lands. The readout the data from such thinner optical discs uses laser light with a smaller wavelength than was used for the 1.2 mm discs. This has entailed a wavelength change from 780 nm to approximately 650 nm or less. Thus, the readout of a higher density of pits and lands, and therefore of more data per disc, is possible with the thinner optical discs. The typical improvement is from 650 mega-bits of data to a 5 giga-bits.

A key feature of the present invention is a method for the injection of molding of compact discs at the very small thickness of 0.6mm. In particular it has been discovered that the requirements of such discs in terms of

their planarity, birefringence, and jitter can be met by a critical sequence of steps during and after the injection of molten plastic into the mold cavity, including allowing the injected plastic to force the mold cavity to partly reopen for a predetermined time (or distance) before closing the mold to its final dimensions.

Brief Description Of The Drawings

Fig. 1a-1d is a schematic drawing of the mold chamber of an injection molding machine during the different stages of the process of the present invention.

Fig. 2 is a graph of the injection molding machine parameters, i.e. mold position, screw position, and clamp pressure during the preferred process of the present invention.

Fig. 3a-b is a graph of a graph of an unacceptable alternative set of parameters demonstrating the criticality of the present invention.

Fig. 4 is a graph of the birefringence of the disc produced by the present invention.

Fig. 5a-b is a histogram of the jitter of the disc produced by the present invention.

Detailed Description Of A Preferred Embodiment

The process for injection molding of 0.6 mm discs from can be described in four steps performed on a commercial plastics injection molding machine where the plastic is an optical grade polycarbonate. As shown in Fig. 1, the mold 1 is a cavity one face of which 3 is optically flat, and the other face 5 is a nickel impression of a compact disc. A channel 7 is filled with a molten polycarbonate which

is driven into the chamber 2 of the mold by an advancing screw 11. The faces of the mold, 3 and 5 may be moved closer together by a driving mechanism (not shown). The dimensions of the mold are exaggerated in Fig. 1a-1d. The typical diameter of the face 5 is 120 mm, while the mold opening 9 has an separation of the faces of less than 1600 μ . The polycarbonate 13 is not forced into the mold cavity until the mold cavity reaches an interim position, at which point, as shown in Fig. 1b, the molten polymer 13 is injected into the mold cavity by an injection force due to the advance of the screw 11.

As the injection force exceeds the closing force, the mold cavity is opened slightly, as shown in Fig. 1c.

As the closing force exceeds the opening force, the closing of the cavity is brought to the final dimension as in Fig. 1d.

It has been discovered that a particular set of parameters guiding the injection process are particularly suited to the production of a 0.6 mm compact disc having less than about 0.6 degrees of tilt and sufficiently minimal deviation in pit lengths (jitter). In particular, the preferred embodiment of this invention for a disc having a radius of approximately 60 mm is as follows, as depicted in Figure 2.

The mold is open 900 μ . It is then closed to an interim position of 100 μ and injection of the polymer is begun. Before the full charge of polymer is injected, the injection pressure exceeds the clamp pressure and the mold begins to open. When the injection is completed, and during the next 0.07 seconds, the mold continues to be forced open to 300 μ

and then begin to close. At the end of the positive 0.07 seconds delay the mold is clamped with full force.

5 In order to demonstrate the criticality of these parameter values, the figures show the result of delays of positive seconds and negative 0.25 seconds, both of which result in unplayable discs emerging from the injection molding process. The tables show the results
10 of the three examples of the patent.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to preferred
15 embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. A process for the injection molding of a compact disc made from a polymer and having a thickness no greater than 0.6 mm comprising

opening the mold,

closing the mold to an interim position of 100μ and commencing the injection of the polymer, such that before the full charge of polymer is injected, the injection pressure exceeds the clamp pressure and the mold begins to open,

delaying the compression of the mold for 0.07 seconds, during which the mold continues to be forced open to 300μ and then begin to close,

clamping the mold with full force.

2. A process for the injection molding of a compact disc made from a polymer and having a thickness no greater than 0.6 mm comprising

opening the mold,

closing the mold to an interim position and commencing the injection of the polymer, such that before the full charge of polymer is injected, the injection pressure exceeds the clamp pressure and the mold begins to open,

delaying the compression of the mold for 0.07 seconds, during which the mold continues to be forced open and then begin to close,

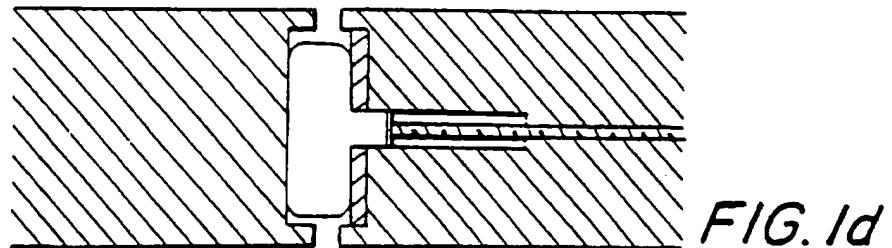
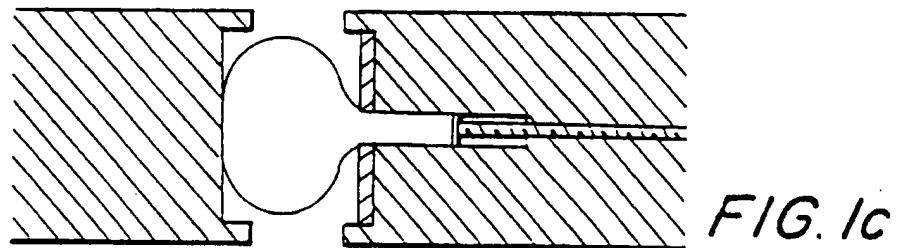
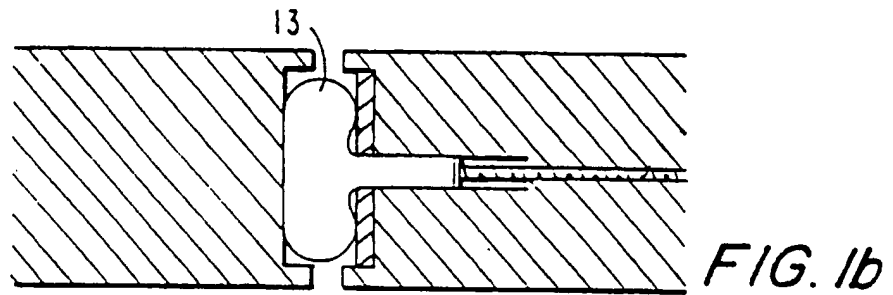
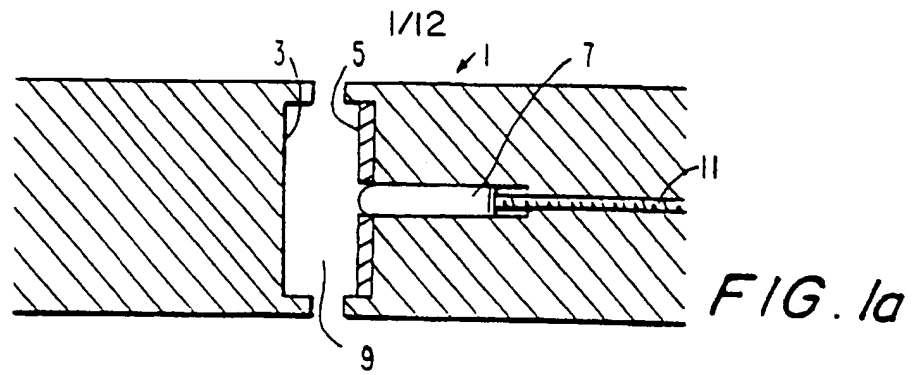
clamping the mold with full force.

3. A compact disc formed by the injection molding of a polymer and having a thickness no greater than 0.6 mm, said disc having a birefringence less than 150 and a tilt less than 0.6 degrees formed by the process of

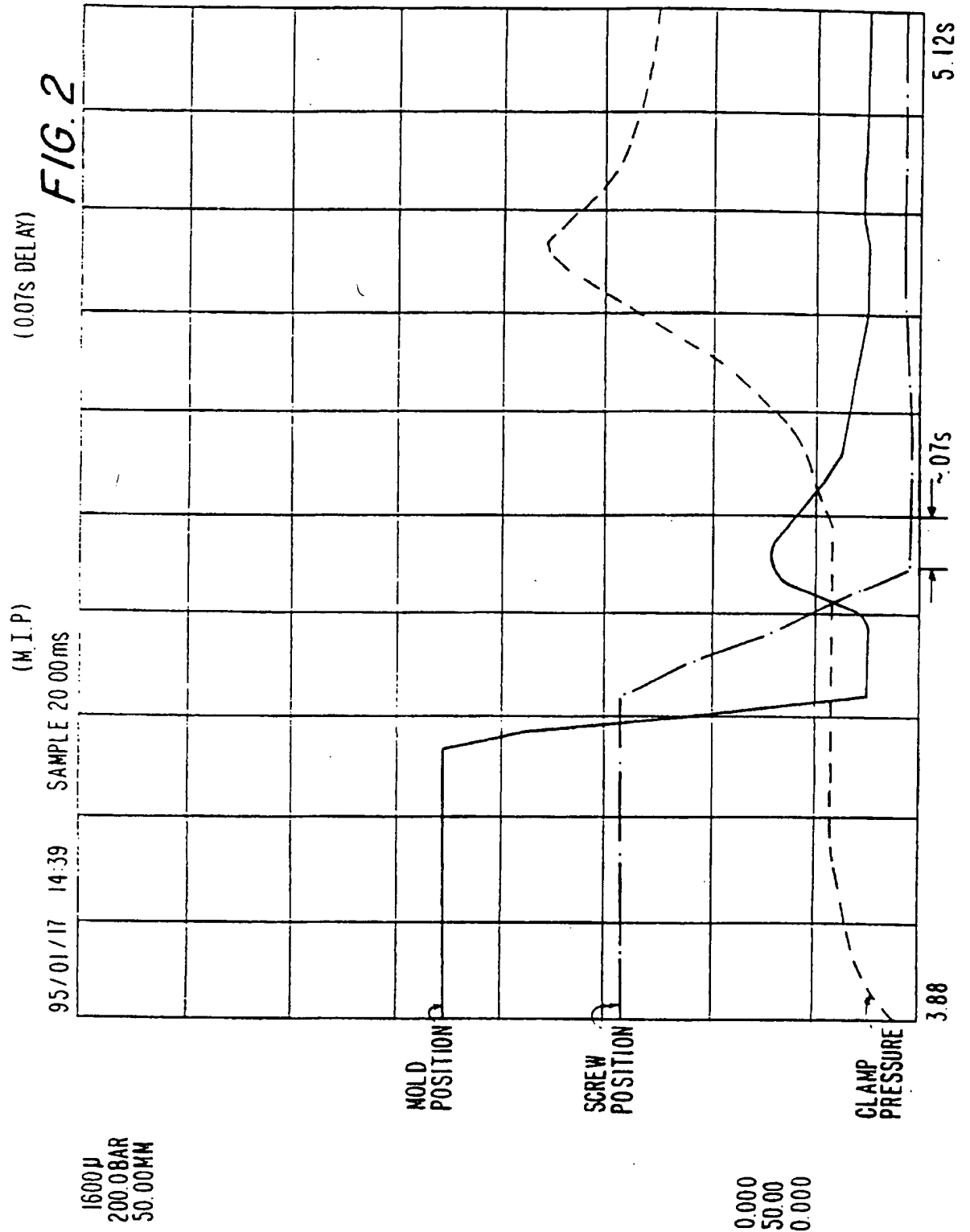
5 opening the mold,
closing the mold to an interim position of 100 μ and commencing the injection of the polymer, such that before the full

10 charge of polymer is injected, the injection pressure exceeds the clamp pressure and the mold begins to open,
delaying the compression of the mold for 0.07 seconds, during which the mold

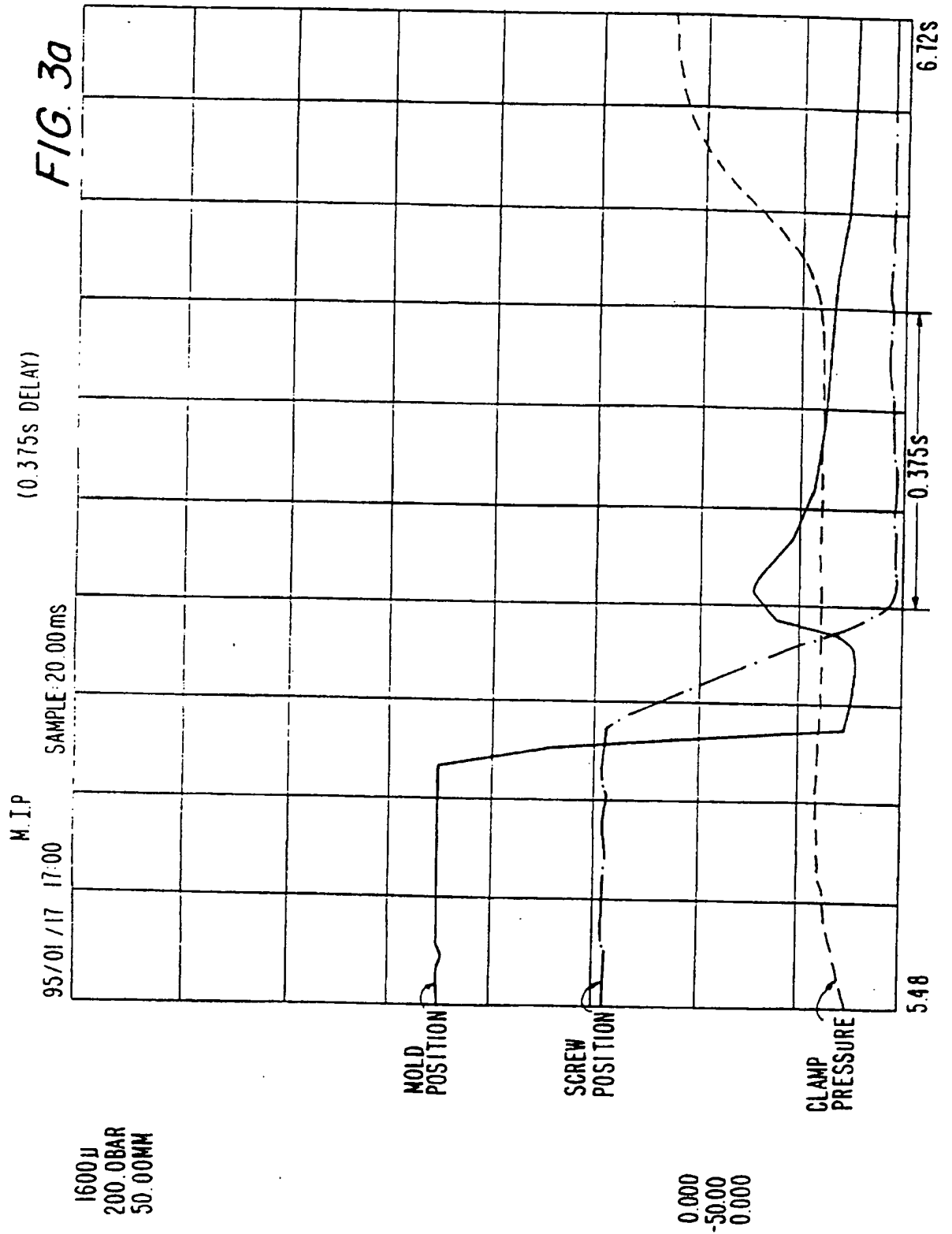
15 continues to be forced open to 300 μ and then begin to close,
clamping the mold with full force.



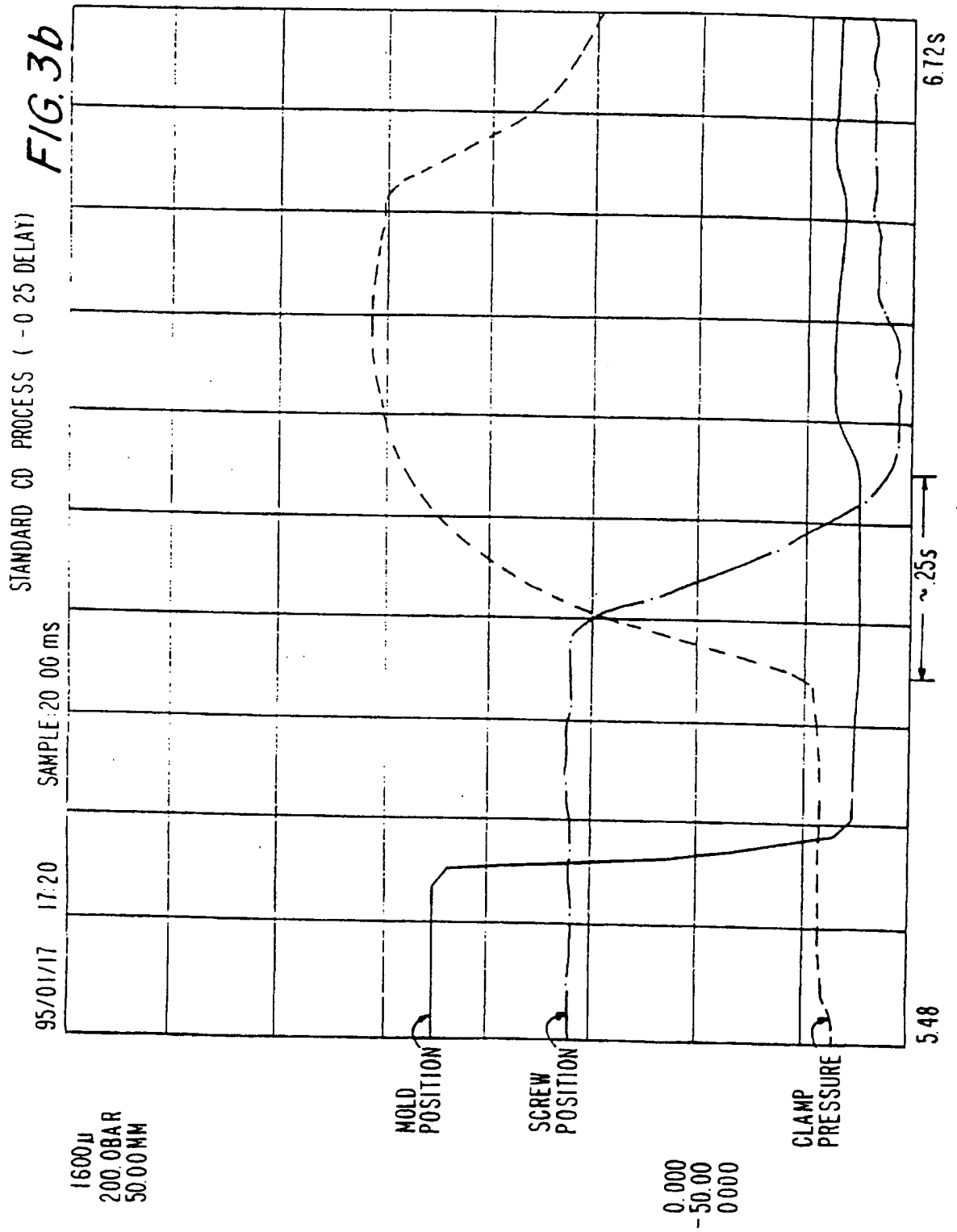
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3/12



4 / 12

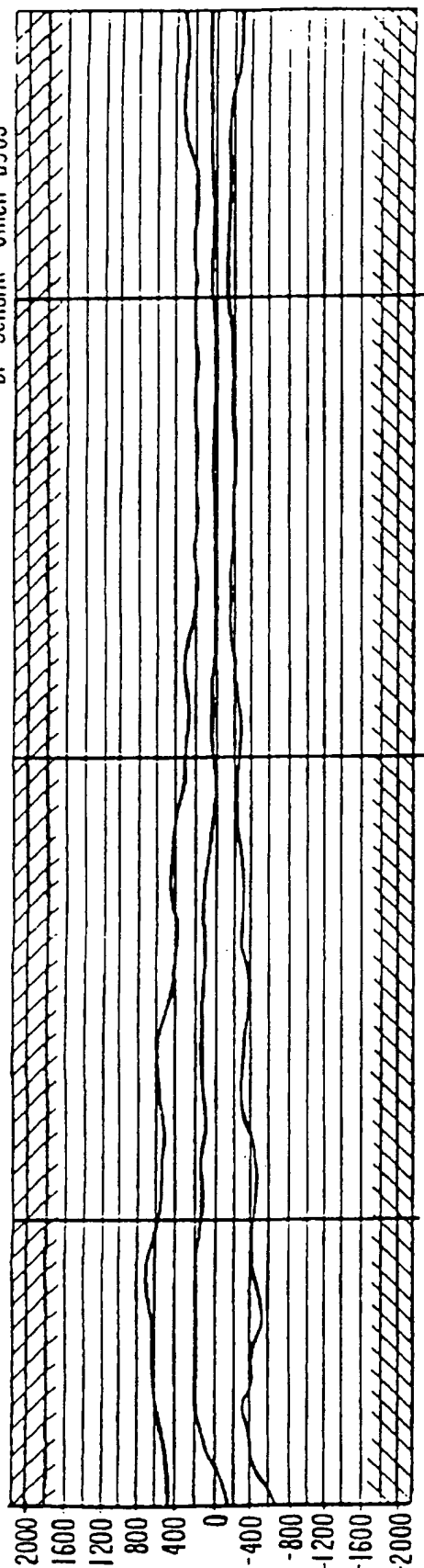


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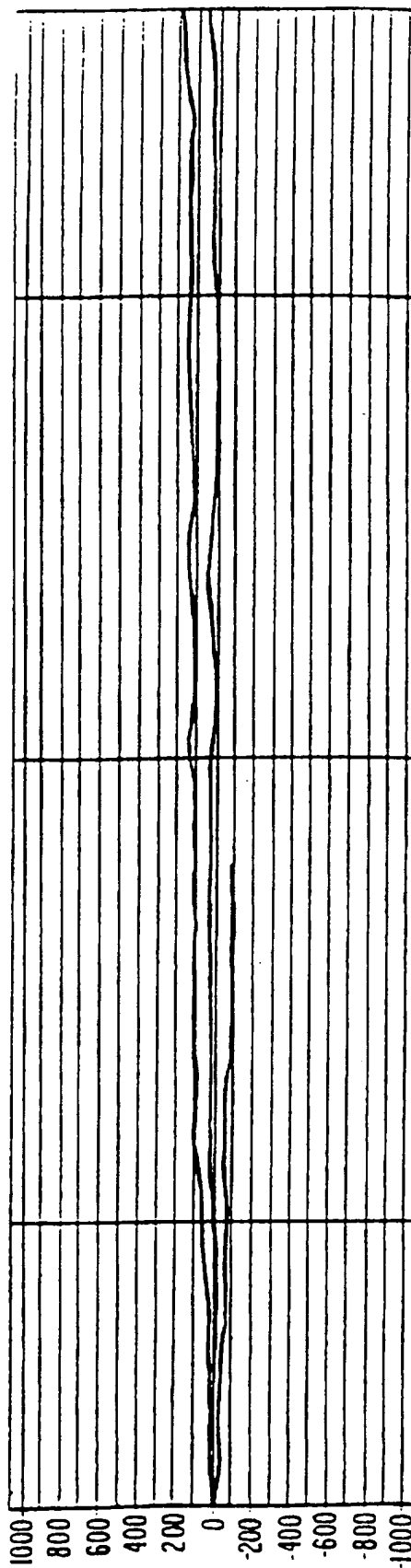
FIG. 4a-1

DIAMETER 120 MM / metallized

DISHING ANGLE (MILLI-DEGREES)
ACTUAL MEASUREMENT



DISHING - LEVEL (MICRONS) (1/1000 mm)

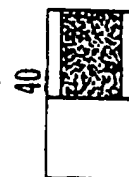


MIN: 50
MAX: 47.3

Reflec. (mean) (%)
Diff. Eff. R. (%)

MIN: -15
MAX: 95

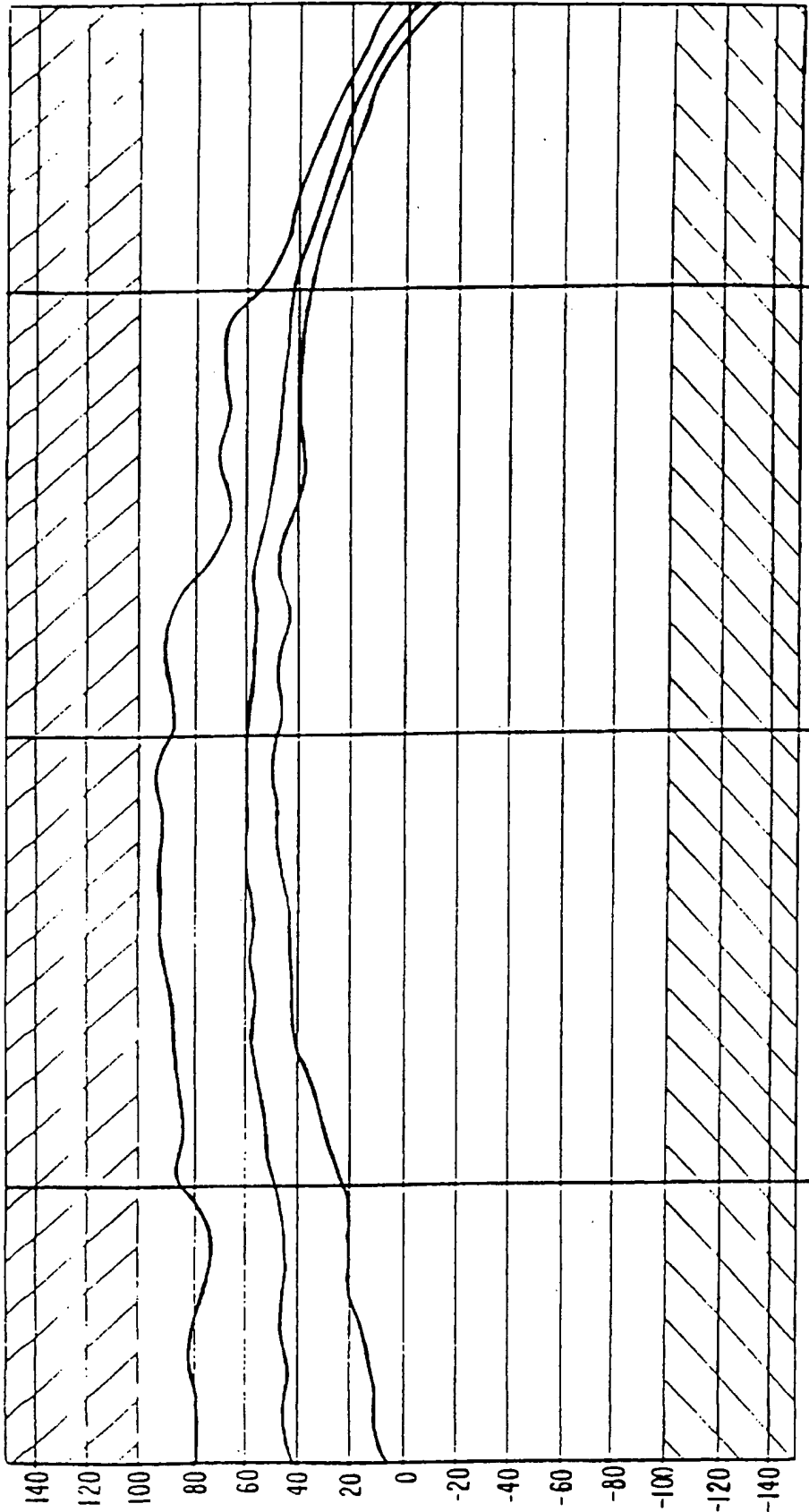
Biref. REFL. (nm)
Dishing abs (deg)
Dishing abs (mm)



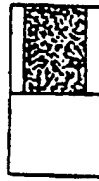
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FIG. 4a-2

BIREFRINGENCE REFLEC (NANOMETERS) DIAMETER 120 MM / metallized
ACTUAL MEASUREMENT



	MIN	MAX
Reflec. (mean) (%)	47.3	61.9
Diff Eff. R. (%)	0.0	0.9



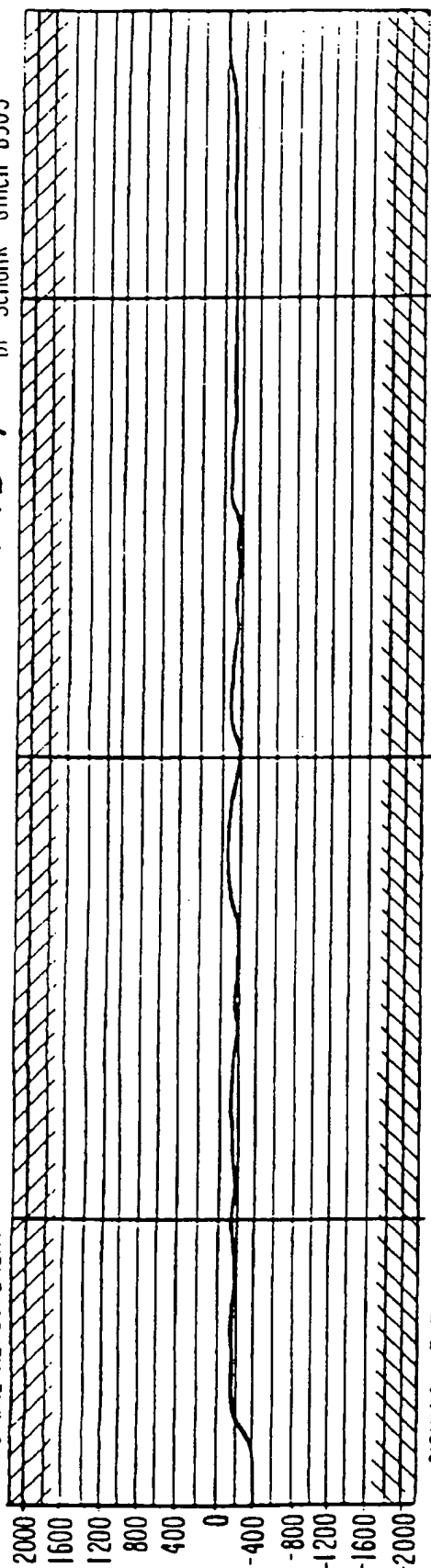
	MIN	MAX
Biref REFL. (nm)	-15	95
Dishing abs (deg)		0.6
Dishing abs (mm)		0.163

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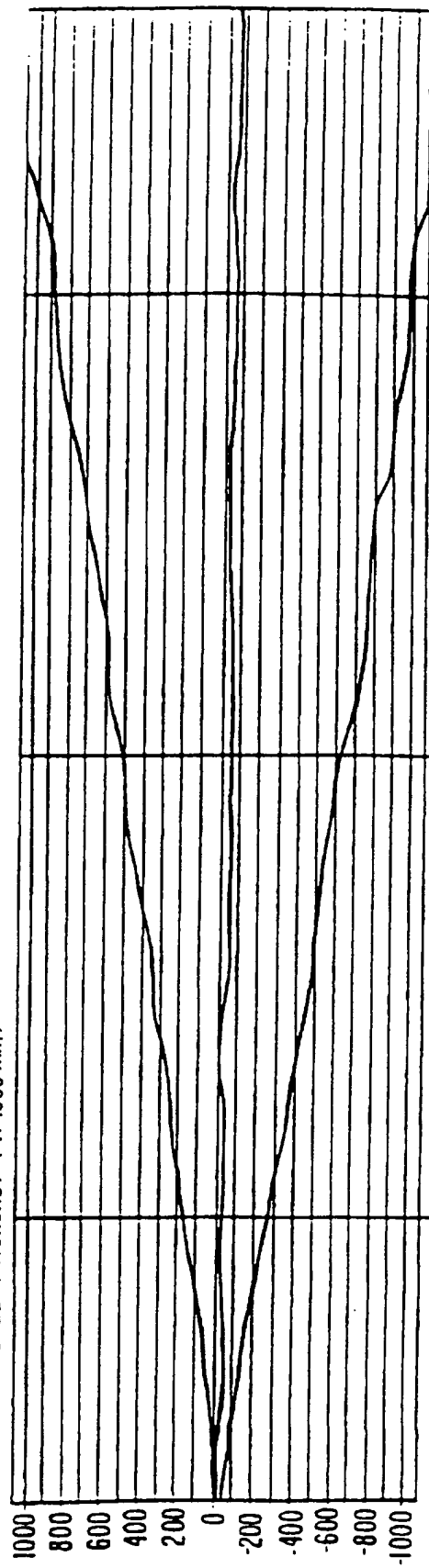
FIG. 4b-1
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DIAMETER 20MM / metallized

DISHING ANGLE (MILLI-DEGREES)
ACTUAL MEASUREMENT



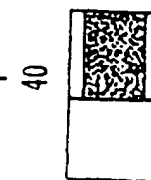
DISHING - LEVEL (MICRONS) (1/1000 mm)



MAX
50.8
1.9

MIN
40.7
0.2

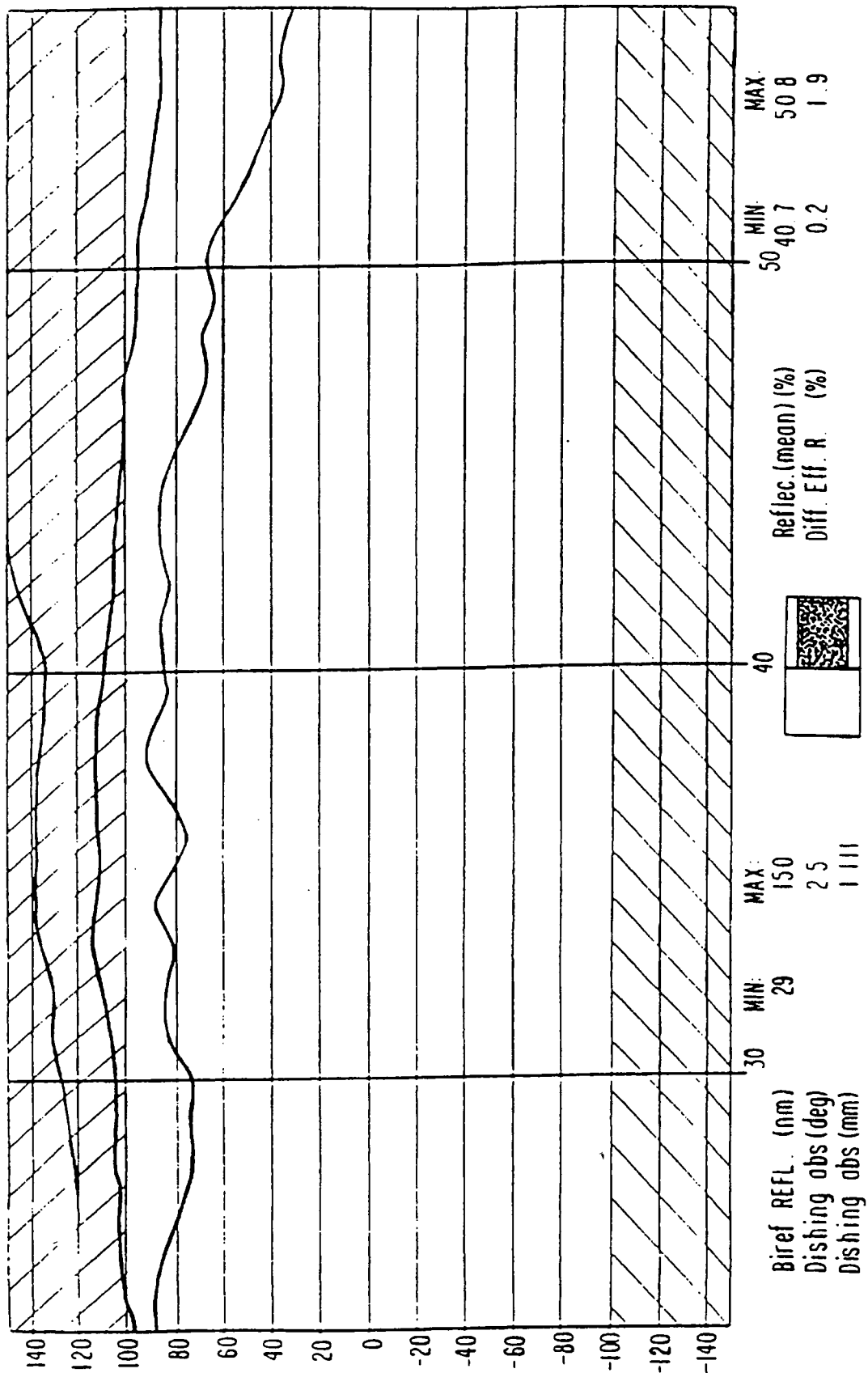
Reflec. (mean) (%)
Diff Eff. R. (%)



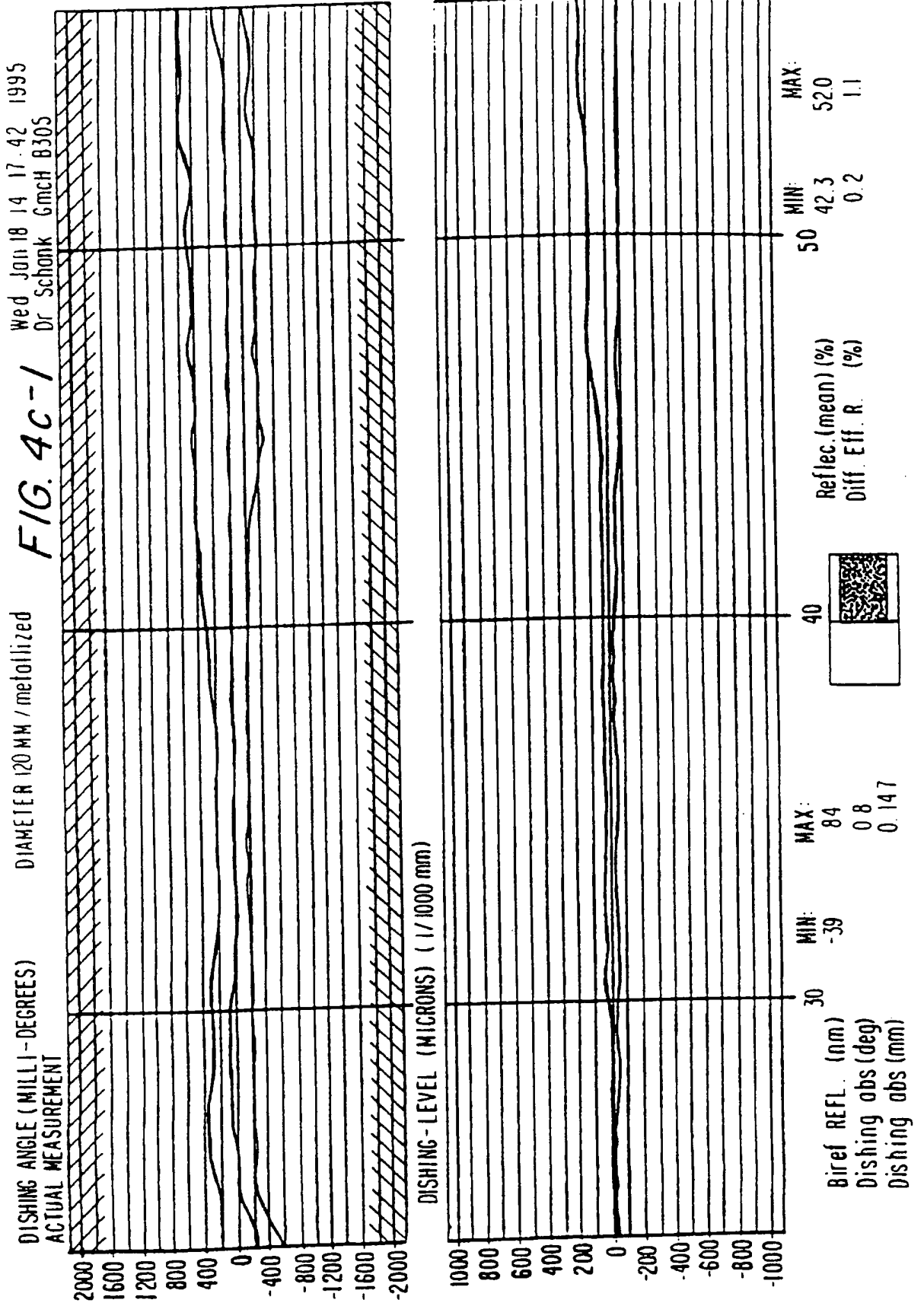
MAX
150
2.5
1.111

MIN
29

Biref REFL. (nm)
Dishing abs (deg)
Dishing abs (mm)

BIREFRINGENCE REFLEC (NANOMETERS)
ACTUAL MEASUREMENT

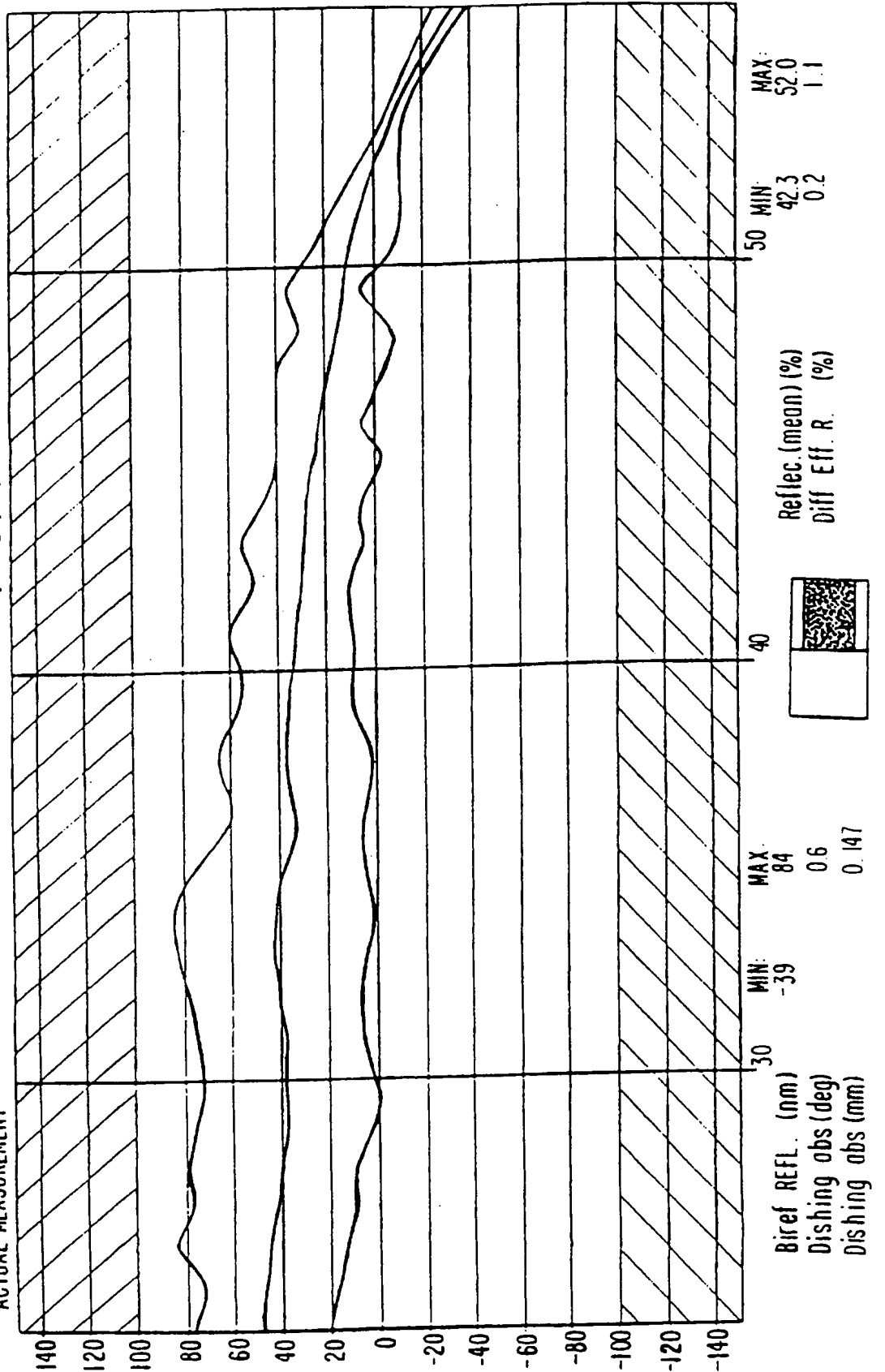
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Wed Jan 18 14 17:42 1995
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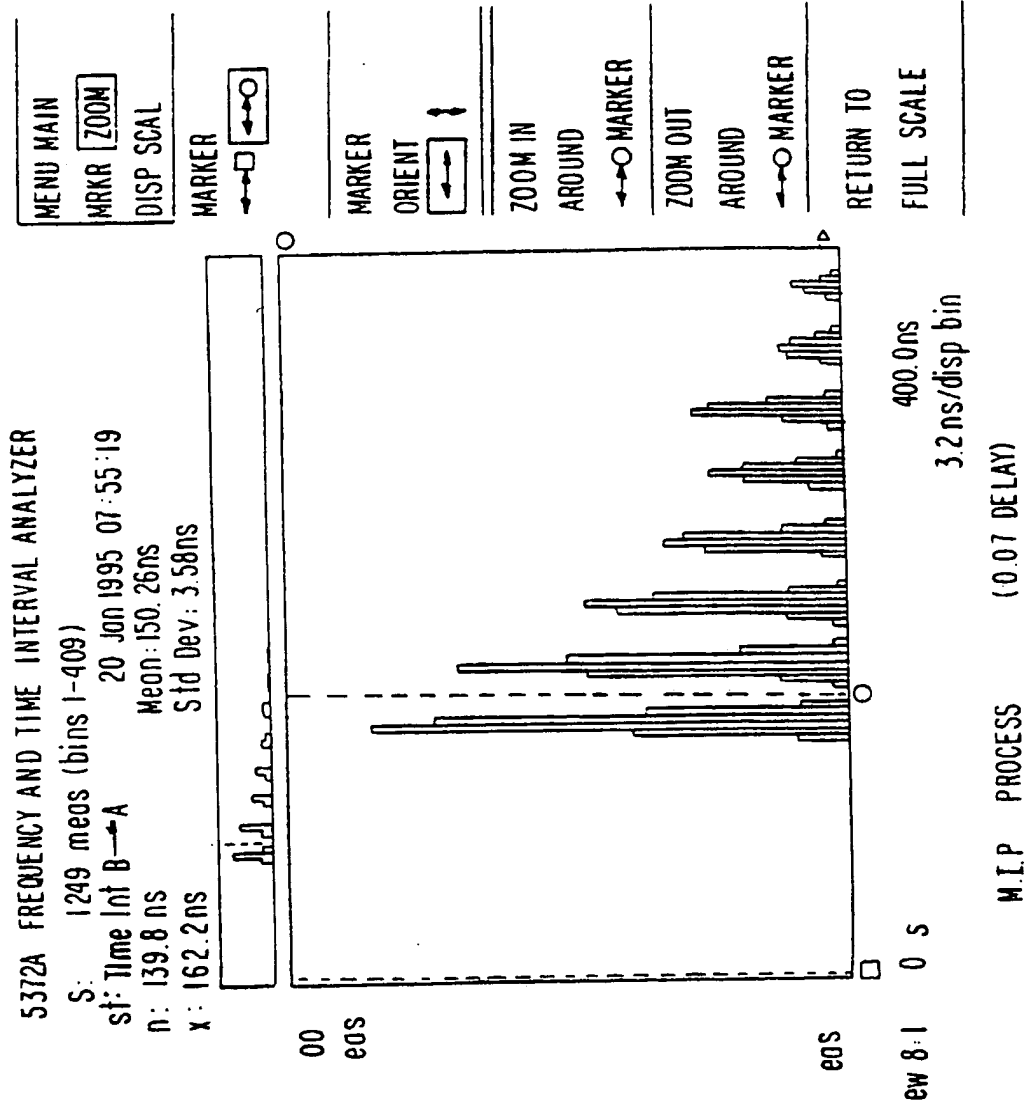
FIG. 4c-2

BIREFRINGENCE REFLEC (NANOMETERS) DIAMETER 120MM /metallized
ACTUAL MEASUREMENT



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FIG. 5a



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FIG. 5b

JITTER 1-19 AT

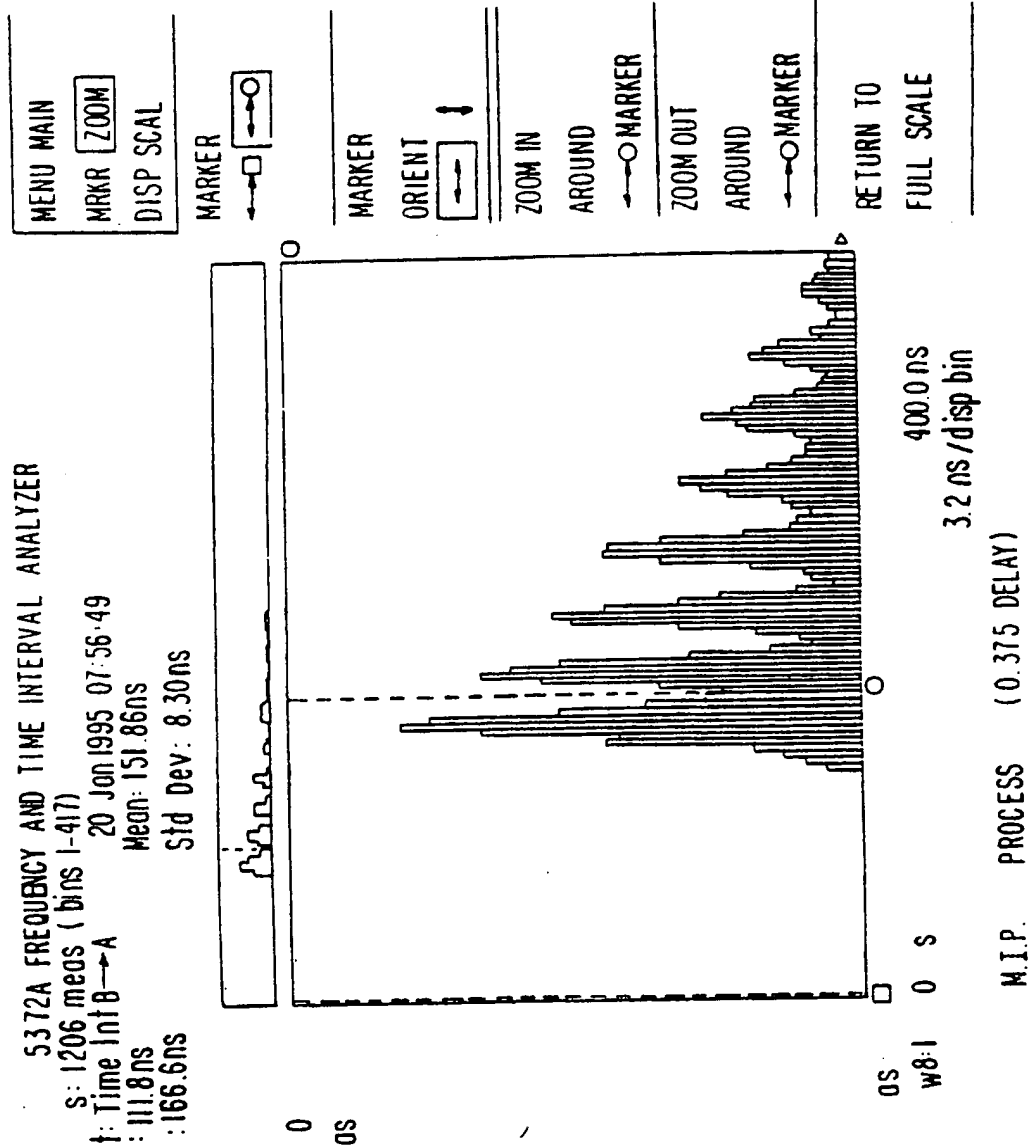
5372A FREQUENCY AND TIME INTERVAL ANALYZER

S: 1206 meas (bins 1-417)

f: Time Int B → A 20 Jan 1995 07:56:49

: 111.8 ns Mean: 151.86 ns

: 166.6 ns Std Dev: 8.30 ns



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB97/01214

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G11B 7/24, 7/26; B29C 45/26, 45/56; B29L 17:00
US CL : 264/1.33, 2.2, 328.7; 369/275.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 264/1.33, 2.2, 40.1, 40.5, 107, 328.1, 328.7, 328.11; 369/275.1; 425/810

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,707,321 A (SEGAWA et al) 17 November 1987, col. 2, lines 49-60.	1-3
Y	JP 5-205323 A (MATSUSHITA ELECTRIC) 13 August 1993, see Abstract.	1-3
A	US 4,879,082 A (KUDO et al) 07 November 1989.	
A	US 4,849,151 A (TAMURA et al) 18 July 1989.	
A	US 4,979,891 A (KITAMURA) 25 December 1990.	
A	US 5,015,426 A (MAUS et al) 14 May 1991.	
A	US 5,044,925 A (WATANABE) 03 September 1991.	

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Date of the actual completion of the international search
17 DECEMBER 1997

Date of mailing of the international search report
30 JAN 1998

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Telephone No. (703) 308-0673

INTERNATIONAL SEARCH REPORTInternational application No.
PCT/IB97/01214**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,068,065 A (MAUS et al) 26 November 1991.	
A	US 5,451,363 A (MINAMIMURA et al) 19 September 1995.	
A	US 5,552,094 A (KUBOTA) 03 September 1996.	
A	JP 5-205324 A (MATSUSHITA ELECTRIC) 13 August 1993.	
A	JP 8-66945 A (MATSUSHITA DENKI SANGYO) 12 March 1996.	